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SEDS1 MISSION SOFTWARE VERIFICATION USING A SIGNAL SIMULATOR

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BACKGROUND

The first flight of the Small Expendable Deployer System (SEDS1) is scheduled as the secondary payload of a Delta II in late 1992. The objective of the SEDS1 mission is to collect data to validate the concept of tethered satellite systems and to verify computer simulations used to predict their behavior. SEDS1 will deploy a 50 lb. instrumented satellite as an end mass using a 20 km tether. Langley Research Center is providing the end mass instrumentation, while the Marshall Space Flight Center is designing and building the deployer. The objective of the experiment is to test the SEDS design concept by demonstrating that the system will satisfactorily deploy the full 20 km tether without stopping prematurely, come to a smooth stop on the application of a brake, and cut the tether at the proper time after it swings to the local vertical. Also, SEDS1 will collect data which will be used to test the accuracy of tether dynamics models used to simulate this type of deployment. The experiment will last about 1.5 hours and complete approximately 1.5 orbits.

Radar tracking of the Delta II and end mass is planned. In addition, the SEDS1 on-board computer will continuously record, store, and transmit mission data over the Delta II S-Band telemetry system. The Data System will count tether windings as the tether unwinds, log the times of each turn and other mission events, monitor tether tension, and record the temperature of system components. A summary of the measurements taken during the SEDS1 shown in Table 1. The Data System will also control the tether brake and cutter mechanisms.

Two major sections of the flight software, the data telemetry modules and the data collection modules, were developed and tested under the 1990 NASA/ASEE Summer Faculty Fellowship Program. To facilitate the debugging of these software modules, a prototype SEDS Data System was programmed to simulate turn count signals. During the 1991 summer program, the concept of simulating signals produced by the SEDS electronics systems and circuits has been expanded and more precisely defined. This signal simulator will be used to debug and test the entire SEDS1 Mission Software.

SEDS MISSION SOFTWARE VERIFICATION TEST SPECIFICATION

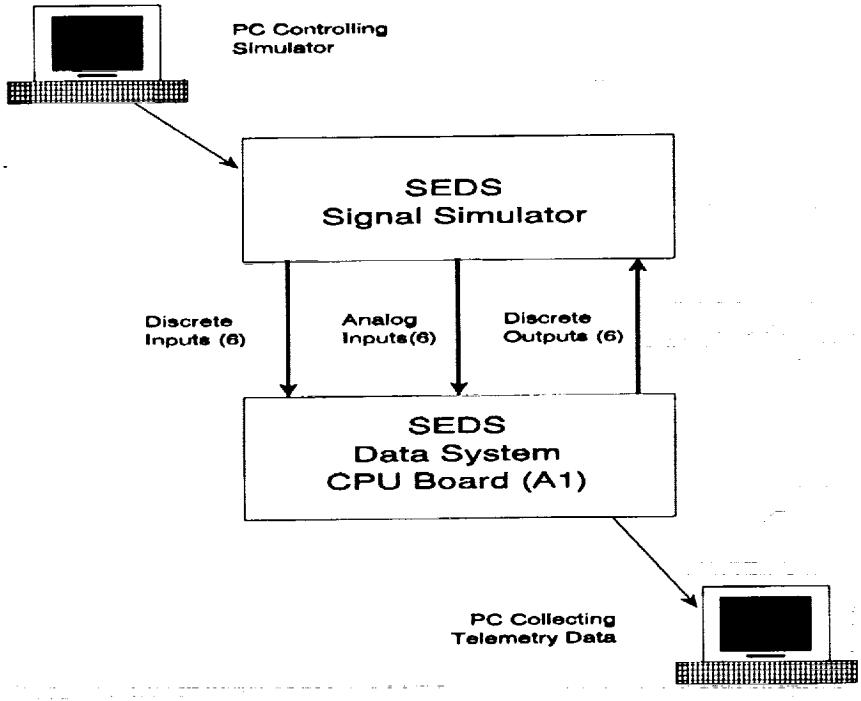
A series of tests will be performed to exercise the software modules which make up the Mission Software of the SEDS Data System. These tests will be performed by using a SEDS Signal Simulator to generate signals which will simulate the inputs normally produced by sensors and circuits in the SEDS system. The test configuration is depicted in Figure 1. A SEDS Data System CPU Card will be modified to construct the SEDS Signal Simulator.

Signals will be generated which simulate both nominal flight conditions and all anticipated anomalies. In addition, the tests provide a means for monitoring and analyzing outputs produced by the SEDS Mission Software for controlling the tether brake and cutter mechanisms.

Table 1. SEDS Measurements

MEASUREMENT	RANGE	SAMPLE RATE
T1 - Tether Temperature	-30° to +80° F	1 per 10 seconds
T2 - Brake Temperature	-30° to +80° F	1 per 10 seconds
T3 - Cannister Temperature	-30° to +80° F	1 per 10 seconds
T4 - Electronics Temperature	-30° to +80° F	1 per 10 seconds
B1 - Turn Counter Beam #1	Discrete	Asynchronous
B2 - Turn Counter Beam #2	Discrete	Asynchronous
B3 - Turn Counter Beam #3	Discrete	Asynchronous
F1 - Tether Tension #1	-0.25 to +0.25 N.	500 per second
F2 - Tether Tension #2	-2.5 to +7.5 N.	500 per second
IN1/IN2- Satellite Deployment	Discrete	Asynchronous

FIGURE 1. SEDS MISSION SOFTWARE TESTING USING A SIGNAL SIMULATOR



With the exception of control signals for the tether brake and cutter, correct operation of the Mission Software can be verified by examining the data collected and transmitted by the Mission Software over the serial port of the SEDS Data System. An IBM-compatible PC will be connected to this serial port to collect the

mission data. The PC will execute software to display summary data contained in the Master Frames sent by the SEDS Data System. In addition, this software will store the serial data in a disk file to be used in post-test analysis and documentation. The signals generated by the SEDS Data System to control the tether brake and the tether cutter cannot be analyzed by monitoring the serial data stream. Therefore, the PC controlling the SEDS Signal Simulator will monitor, display and store these control signals levels.

There will be two groups of tests performed on the SEDS Mission Software using simulated input signals: Turn Counter Tests and Mission Simulation Tests. The Turn Counter Tests will focus on modules which execute the turn count functions of the Mission Software and exercise these modules under both normal and anticipated anomalous conditions. The Mission Simulation Tests will emulate the complete SEDS experiment cycle and will be designed to represent both normal and anticipated anomalous conditions. The Turn Counter Tests are described in Table 2, and the Mission Simulation Tests are described in Table 3.

TABLE 2. TURN COUNTER TESTS

TEST	CHANNEL-A	CHANNEL-B	OTHER
1	No failure, no flutter	No failure, no flutter	No pre-deployment turn count activity
2	No failure, no flutter	No failure, no flutter	2 sec. of pre-deployment activity on Channel-A
3	No failure, flutter present	No failure, no flutter	No pre-deployment turn count activity
4	No failure, no flutter	No failure, flutter present	No pre-deployment activity
5	Failed at 0.5s	No failure	No pre-deployment turn counts or flutter
6	No failure	Failed at 0.5s	No pre-deployment turn counts or flutter
7	Failed at 0.5s, normal at 2.5s	No failure	No pre-deployment turn counts or flutter
8	No failure	Failed at 0.5s, normal at 2.5s	No pre-deployment turn counts or flutter
9	No failure, occurs before Ch.-B	Overlaps Ch.-A in same 2ms interval	No pre-deployment turn counts or flutter
10	Overlaps Ch.-B in same 2ms interval	No failure, occurs before Ch.-A	No pre-deployment turn counts or flutter

During each of the SEDS Mission Simulation Tests, the SEDS Simulator will generate independent signals to each analog input of the SEDS unit under test. The analog signals provided by the simulator will be one of three levels: 0v (0.2v, max), half-scale (2.5v $\pm$10%), or full-scale (5.0v$\pm$10%) and will be applied in regular

cycles. The purpose of applying simulated analog inputs to the SEDS Data System is not to gauge the accuracy of the A/D converter circuitry but to assure that the data collection modules in the Mission Software is correctly collecting and transmitting temperature and tension information.

TABLE 3. MISSION SIMULATION TESTS

	CHANNEL-A	CHANNEL-B	BRAKE ENABLE SWITCH
1	No failure	No failure	Asserted after 40,000 counts on Channel-A
2	No failure	Fails after 10,000 counts	Asserted after 40,000 counts on Channel-A
3	Fails after 10,000 counts	No failure	Asserted after 40,000 counts on Channel-B
4	No failure	Fails after 10,000 counts	Not asserted
5	Fails after 10,000 counts	No failure	Not asserted

CONCLUSION

The SEDS Signal Simulator will be used in the debugging and in the formal verification of the SEDS1 Mission Software. The Simulator will not only emulate normal flight conditions but also exercise all modules written to handle anticipated anomalous flight conditions, conditions that would be difficult to reproduce and control with actual SEDS hardware. The simulator will help to expedite software development and to increase the confidence of the users of the Mission Software. With little modification, the Simulator should be useful in the software development of future SEDS flights.

REFERENCES

1. "SEDS Data System Functional Requirements", Energy Sciences Laboratories, Inc. and Program Development, MSFC, May 1988.

2. "SEDS Data System Data Collection and Telemetry Software", Final Report, NASA/ASEE 1990 Summer Faculty Fellowship Program, Contract No. NGT-01-002-099, MSFC, Huntsville, AL.

3. "SEDS Mission Software Verification Test Procedures, NASA/ASEE 1991 Summer Faculty Fellowship Program, Contract No. NGT-01-008-021, MSFC, Huntsville, AL.

4. "MSFC Software Management and Development Requirements Manual", Software and Data Management Division, January, 1991, MSFC, Huntsville, AL.